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SHORT COMMUNICATIONS

Spectral Diagnostics of Plasma Discharge between a Metal Cathode and Liquid Anode

Al. F. Gaisin[a], *, E. E. Son[b], A. V. Efimov[b], A. Kh. Gil'mutdinov[a], and N. F. Kashapov[c]

[a] *Tupolev Kazan National Research Technical University, Kazan, 420111 Tatarstan, Russia*
[b] *Joint Institute for High Temperatures, Russian Academy of Sciences, Moscow, 127412 Russia*
[c] *Kazan Federal University, Kazan, 420008 Tatarstan, Russia*
**e-mail: almaz87@mail.ru*

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Abstract—The results from studies of an electric discharge between a metal cathode and liquid anode at atmospheric pressure are presented. We investigate the discharge shape, the plasma emission spectrum, the electron concentration and temperature, and the molecule temperature; we analyze the continuous emission in the plasma spectrum and perform infrared thermography.

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INTRODUCTION

Along with studies of low-temperature plasmas of gas discharges between solid electrodes, researchers are paying more attention to the discharges generated in the interelectrode space where one or both electrodes are liquid. Such discharges are generated by AC or DC in volume (diffuse) and in microchannel forms. The discharge parameters depend on the electrical characteristics, composition, and pressure of the ambient gas; on the shape and brand of the solid electrodes; and on the composition and concentration of the liquid electrodes.

Electrical, gas-dynamic, thermal, and spectral characteristics of the discharge; plasma component concentrations and energy distributions; types and shapes of the discharges; and theory and numerical modeling of the discharge ignition and burning at the boundary of two media are all objects of investigation. Those discharges gain still wider applications in the solution to different technological problems, such as surface modification of metal goods (including those produced using additive technologies, water and air sterilization, and electrolyte-plasma welding), ozone production, etc.

Yet, despite the wide range of interests and applications of such discharges, the problems of plasma composition, and concentration and temperature distribution of plasma components are still insufficiently investigated.

Recently, in Russia (e.g. [1–18]) and abroad, in particular, in Japan and Slovakia [19–21], researchers from various scientific schools investigate the physical processes in electric discharges with liquid electrodes and their applications, and the number of such schools is still increasing. The present work is aimed at the investigation of the emission spectrum, and concentration and temperature of electrons and hard components of the plasma of electrical discharge between the metal cathode and the liquid electrolyte anode at atmospheric pressure.

EXPERIMENTAL FACILITY AND RESULTS

We studied the discharge between the metal (the 18/10 steel) and the liquid anode (the 7% NaCl solution in technical water) at $U = 600$ V, discharge current of $I = 12$ A, pressure of $p = 10^5$ Pa, cylindrical cathode diameter of $d_c = 8$ mm, and specific electrolyte conductivity of $\sigma = 0.12\ \Omega^{-1}\ \text{cm}^{-1}$.

To solve the posed problem, we applied the following investigation methods:

1. We registered the discharge plasma burning process by means of the SONY FDR-AX33 digital photocamcorder.

2. We measured the electrical discharge characteristics by means of the Fluke digital multimeter with a basic error of 0.025%.

3. We registered the emission spectrum of the discharge by means of the PLASUS EC150201MC optical fiber spectrometer within the wavelength range of 195–1105 nm. We decoded the spectrum throughline identification by comparing the investigated spectrum with the NIST database.

4. For the infrared thermography as well as for verification of the temperature distributions over the metal cathode and the liquid anode, we applied the FLIRA6500SC infrared imager and processed the obtained infrared data using the ALTAIR v5.91.010 software.